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## THE LEAF

The glossy, dark green leaflets are deepest in color when in the sun, pale underneath, generally 3 in number, although sometimes 5, orbicular to ovate or oblong-ovate, undulate or plane, entire or variously lobed, segmented or toothed, 1 to 4 inches long. The 5-leaflet variety, according to Brandege (3) is quite common on the Santa Barbara Islands. Leaves having 5 leaflets are also found on plants which have a majority of the 3-leaflet kind. Leaflets are singularly variable in size, outline, and segmentation, even on the same plant. This fact constitutes one of the most remarkable features of the plant and is the principal basis for its differentiation from *Rhus Toxicodendron* L. Leaf tracings (21) made from mature leaves collected by the writer at Berkeley, California, on September 27, 1916, were taken from plants within a radius of 100 feet, all of which were enjoying the same soil and exposure and had no apparent cause for such marked differences in leaf shape.

Leaves in the sun differ from those in the shade, not only as regards color but also in several structural details. The young leaves are covered with hairs, which dry out and fall off as the leaves become fully matured. These hairs are apparently more frequent on leaves exposed to the sun than on those in the shade. Other differences will be described later.

In autumn, as in spring and summer, the plant is singularly attractive, its leaves turning many shades of red, yellow, and brown. This color change may be induced in mature leaves in midsummer by certain insect injuries, by attacks of fungi, or by an interference with the flow of sap caused by twisting the stem. There is no apparent difference between the leaves of male and female plants in this respect. Some plants, however, particularly those in the shade, may have all their leaves yellow. Conversely, red leaves seem to be peculiar to plants of sunny exposure, although there are many exceptions; far more frequently the leaves are mixtures of all three colors. The oldest leaves often assume autumnal tints first.

The petiole in transverse section (21) has in form nearly a semi-circle for its dorsal side and a small concave arc as a ventral surface. Under the epidermis lie two or three layers of collenchyma cells. The vascular bundles, of which there are more than 18, are arranged in a flattened circle parallel to the outer surface of the petiole. The pith consists of large, thin-walled cells with very small triangular intercellular spaces. The vascular bundles are separated from each other by broad medullary rays. Large resin ducts are found in the phloem. The primary cortex is bordered internally by a starch sheath. The cells of the xylem have thick and lignified walls. The pith is enclosed by bast fibers and xylem and takes up the largest part of the section. There are no resin ducts in the pith or in the primary cortex.

The leaf in transverse section exhibits palisade parenchyma occupying about one third of the entire thickness of the mesophyl (Pl. III, fig. 4). The spongy parenchyma occupies about five layers of cells. Cells with

crystal clusters, presumably of calcium oxalate, occur in the palisade parenchyma. The cells of the lower epidermis are similar to those of the upper epidermis but smaller; stomata are very frequent and apparently absent from the ridges. The leaves wilt very easily. It is hardly possible to bring a cut branch from the field to the laboratory without observing wilting. There are two kinds of trichomes on the leaves, multicellular club-shaped, and unicellular or multicellular bristle-shaped (21).

The thick-walled bristle hairs occur mainly on the lower side on the ridges, large and small, of the leaf, although they are found also in fewer numbers on the upper side in corresponding places. The club-shaped trichomes, on the other hand, are found mostly between the ridges of the leaves. These two different forms of trichomes are similar to those found by Möbius (22) on *Rhus vernicifera* L. and by Rost and Gilg (24) on *Rhus Toxicodendron* L. Morphologically the club-shaped hairs seem to be glandular: first, because the upper multicellular portion is sharply marked off from the basal portion, which resembles a stalk; second, the upper portion has thinner walls than the basal portion; third, they are found mostly on the young, rapidly growing organs of the plant, especially the floral region and the leaves, less on the green stem, and hardly at all on the woody portion. Schwalbe (25, 26) considered the poison of *Rhus diversiloba* to be excreted from glandular hairs on the surface of the plant. That such is not the case can be shown by the two following experiments:

(1) When the green stem, pedicel, or main ribs of the leaf, which are covered with trichomes, are rubbed on sensitive skin, no dermatitis results. Care must be taken, however, that the epidermis of the plant is not broken severely enough to cause the resinous sap to exude.

(2) The fresh green leaves were placed in a finger bowl and soaked at room temperature in 95 percent alcohol for 10 minutes. The leaves had been examined first under a hand lens to make sure that through possible injury no resinous sap was on the surface. When placed in the finger bowl the sap was prevented from running down the pedicel from the cut end into the alcohol. The leaves when taken out of the alcohol had lost their gloss. The pale yellowish alcoholic solution remaining was concentrated by boiling in an open beaker. It was found to be non-toxic. It was not darkened by potassium hydroxide, nor did it respond to other chemical tests for the poison. These results indicate that neither the plant trichomes nor their exudate is poisonous.

The club-shaped hairs are so minute as to be hardly discernible by the naked eye. They have a length of 0.071 mm. and a maximum breadth of 0.0027 mm. Under the microscope they exhibit a clear, unicellular basal portion as an outgrowth of an epidermal cell, above which are the numerous cells that go to make up the main portion of the hair. The cells of the main portion when viewed transversely radiate from a longitudinal central axis. The apex terminates in a single cell, and the entire main portion of the hair

is enclosed in a thin-walled sac. The hairs appear to be of two types, which apparently correspond to different stages in development: a densely granular and a sparsely granular form. This difference in granular density is interesting. In animal glands it has long been noticed that when a serous gland has been quiescent for several hours the secretory cells are granular throughout, and the outlines of the cells are only faintly marked as clear lines bounding the granular areas. When the gland secretes, many of the granules disappear and after prolonged secretion very few granules are left; *i.e.*, during secretion the granules normally contained by the cells are in some way or other used up, probably to form a part of the secretion. Although the diminution of zymogen granules is a normal occurrence in the secretion of the salivary, infra-orbital, lachrymal, mucous, and pancreatic glands, yet in the case of the mammary glands the opposite is true, *viz.*, that granules begin to form with the commencement of secretion and do not occur during rest. In the mammary gland, the active growth of protoplasm, the formation of granules from the protoplasm, and the discharge of these granules in the secretion appear to go on at one and the same time. Investigation of the club-shaped hairs of *Rhus diversiloba* has not as yet revealed a positively glandular nature, and consequently a relation between differences in their granulation can not be definitely connected with secretion. From a morphological standpoint, however, as above pointed out, the club-shaped hairs seem to be glandular.

Club-shaped hairs from leaves gathered in the morning before sunrise and from those secured in the heat of the day could not be differentiated. Hairs from rapidly growing leaves could not be distinguished from those of old leaves or stems. Hairs from leaves grown in sunny exposures exhibited no differences, although they were present in greater number than on leaves continuously in the shade.

#### THE STEM

A transverse section of a green stem of *Rhus diversiloba* shows, beginning at the outside, the following tissues (Pl. III, fig. 5): epidermis, with its trichomes and stomata; collenchyma; cortical parenchyma; pericycle, with bast fibers and thin-walled pericycle parenchyma; phloem, with resin ducts; cambium; xylem; medullary ray; pith.

As the stem increases in diameter (fig. 3) the cortex develops a phellogen. The continuous activity of the phellogen results in an increasing thickness of the sheet of cork. The chloroplast-containing tissue beneath the cork layer maintains connection with the air by means of lenticels which have replaced the stomata. As may be anticipated, the dead cork cells are non-poisonous, *i.e.*, they do not cause dermatitis when rubbed on the skin of a susceptible individual and therefore do not constitute a means of transference for the poison.

No resin ducts have been found in the pith of this plant. Engler (5),

studying *Rhus Toxicodendron* L., and Inui (10), studying *R. Toxicodendron* var. *radicans*, were unable to discover resin ducts in the pith. Jadin (11) cited 18 species of the genus which are provided with permanent pith resin ducts, and 9 species which do not have them.

At the periphery of the pith the small outer cells acquire a thick wall and become sclerenchymatous. These thick-walled cells may assist the inner large-celled and the outer small-celled pith to maintain a circular outline. A semi-circular row of bast fibers lies external to the primary phloem and serves mechanically to protect the phloem with its resin ducts from external injury.

In the phloem of the second year, new resin ducts appear. These lie neither in radial nor in tangential rows, but are so arranged as to be very nearly equidistant. The first appear in the secondary phloem between two primary resin ducts, and more are formed in a corresponding manner. It must not be forgotten, however, that the formation of resin ducts does not occur in a regular manner.

New bast fibers do not appear to be formed in the pericycle. The epidermis has been almost wholly lost in the second year and is replaced by cork.

The histology of the pith, wood, and bark of the older stems will be treated individually.

The pith cells are polygonal and lie close together; they are generally wider than high, so that their vertical measurement is the smallest. In the specimens examined, the pith cells contained for the most part no particular substance; starch was found sparingly, and tannin sacs appeared as narrow, elongated cells. Tannin sacs, according to Engler (5), appear abundantly in the pith of the Anacardiaceae and in all species of *Rhus* which he investigated. Pith tannin sacs are not necessarily characteristic of toxic species of *Rhus*, as Möbius (22) was unable to find them in *R. vernicifera* L.

The bulk of the wood consists of simple pitted wood fibers. In transverse section they are bordered at right angles, and are assembled in rows. The narrower and thicker-walled cells of the fall wood contain starch; the wider and thinner-walled ones of spring wood appear empty.

The pits of the tracheal vessels are exclusively simple with circular or elliptical outlines. The walls are relatively thick. The structure of the vessel wall, where it is in contact with wood parenchyma, is characteristic. In these places simple pits of large size are found chiefly on the vessel wall, and, side by side with them, either transitional or true bordered pits, but no separate bordered pits were noticed. The elliptical pits are transverse to the longitudinal axis of the vessel and parallel to one another, so that they remind one of scalariform perforations.

The medullary rays are, as a rule, uniseriate; sometimes, however, they are biseriate. In tangential longitudinal section they are from three to eighteen cells high; radially their cells are joined together as are the stones

in a wall of plane ashlar masonry. The walls of their cells are only moderately thickened, and their lumina are often filled with starch. The medullary rays are most noticeable in the lower part of the stem and in the roots. One small root had five primary medullary rays.

The difference between fall and spring wood rests partly on the dissimilarity of the wood fiber cells and partly on that of the vessels. The first tracheals of spring are larger, thicker-walled, and stretched somewhat radially, while those toward the outer border of the annual ring are flattened to smaller, thicker-walled, and radial rings. The vessels in the spring wood are wider and more numerous, in the fall wood narrower and scarcer, as shown in Plate III, figure 3. The breadth of the annual rings varies.

The inner wood is colored yellow or yellow-brown. A great deal of this coloring matter can be extracted with hot alcohol. This extract behaves similarly to the extract of the related species *Rhus Cotinus* L. (*Cotinus coggryia* Scop.) in the following treatment: an orange-yellow solution in water was made bright yellow by hydrochloric acid, yellow-red by ammonia, orange N. with alum and sodium carbonate solution, and brown N. by calcium chloride solution. Such a behavior by no means proves that the solutes from the wood of *Rhus diversiloba* are identical with those from *R. vernicifera*, although such may actually be the case. The coloring matter is naturally attached to the membrane of the wood cells, which appear golden yellow under the microscope and assume a brown color with caustic potash. Besides the yellow crystals, the wood cavities contain a reddish amorphous resinous substance which is likewise soluble in 95 percent alcohol.

The primary cortex contains sclerosed parenchyma.

The structure of the pericycle is characteristic. It contains many bast fibers, which, in transverse section, have the form of arcs whose convex sides are on the exterior and whose inner concave surfaces surround in each case a single, usually large resin duct (Pl. III, fig. 5).

The resin canals in the later-formed portions of the bark have a lumen and are arranged more or less regularly in concentric circles as heretofore described. The old resin canals appear to be obliterated through a kind of tylotic growth. On one transverse section through the bark of an old stem which has already thrown off the primary covering there are many resin canals differing in form, outline, and dimensions. The innermost are open and nearly circular, but usually more strictly oval in shape, stretched tangentially, and of larger circumference than the outer ones. The outermost, particularly in old stem parts, are entirely or almost entirely obliterated through the luxuriant growth of intruding contiguous tissue. It is possible to observe at different heights of the same resin canal different states of development so that in one place it may still be open and in another closed. This occurrence of tyloses in the secretory ducts is similar to that described by Möbius (22) in *Rhus vernicifera* L., by Leblois in *Brucea ferruginea*, and by Conwentz in the intercellular canals of other plants.

The secondary medullary rays, as already noted, are usually constituted of one row of cells. Where biseriate rays are found, it is sometimes noticed that they split apart tangentially while they remain intact radially. From this it would seem that adjacent cells of the two columns of the medullary ray are only loosely united, whereas those cells which constitute a radial row are more firmly attached.

Besides what has already been said regarding the phloem, it should be added that the sieve tubes and their companion cells extend tangentially and build approximately alternating bands with the layers of phloem parenchyma cells, as in the stem section of *Aristolochia Siphon* (27). The phloem apparently has but little starch, which is found deposited chiefly in the medullary rays. These cells also give a distinct reaction for tannin with ferric chloride.

#### MORPHOLOGY AND ANATOMY OF THE ROOT

The root system in its ramifications resembles the crown, in that comparatively few strong branch roots are formed which carry the fine, interlaced roots. The spread of roots depends largely upon the nature of the soil, and upon the supply of food and water. There is a strong tendency to form long lateral roots, particularly in shallow soil. Propagation by layering is very frequently made use of naturally by the plant to insure its food supply and reproduction. The fine, interlacing rootlets are dark brown in color and are covered with fine root hairs of a lighter color. The apical tips of the rootlets are light yellow or colorless for several millimeters.

As in other roots, after the secondary phloem is formed the cambium soon takes on a circular form in section, and behaves in the formation of xylem and phloem exactly as in the stem (Pl. III, fig. 2).

The wood of the root is less firm than that of the stem; there exist numerous large bundles, the fiber cells are less strongly thickened, the medullary rays are broader, being indeed commonly composed of two layers of cells.

#### MORPHOLOGY AND ANATOMY OF THE FLOWERS

*Rhus diversiloba* is strictly dioecious, so far as my observations go. The male and female plants begin to bloom at about the same time. At Berkeley, California, but few of the flowers were open April 4, 1915. The next spring the plants near the Greek Theater at Berkeley bloomed mostly between March 22 and May 1. In 1917 at Pasadena I noticed some male plants at the foot of the Mt. Wilson trail in bloom on the fifth of January. February 28, 1917, the plants of both sexes were just starting to bloom in the Arroyo Seco, south of the Colorado Street bridge, Pasadena. In spite of their yellow-green color, the flower panicles are conspicuously displayed as a result of their size and their accumulation on the ends of the twigs. The presence of the staminate flowers is made very noticeable by their fragrant jasmine or hyacinth aroma. The pistillate flowers, on the other hand,



have no apparent perfume. At this point it may be well to mention that an aromatic perfume so similar as to be perhaps identical is noticed when the fresh end of a freshly broken branch is smelled, and that this perfume, unlike that of the flowers, is not confined to the male plant, but is observed also in the female. The similarity between the perfume of the sap and that of the flower becomes more marked upon purification. The "aqueous solution" as made and described in a previous paper (18) contains this more purified sap perfume. The panicles of the male and female flowers are somewhat differentiated as to location and structure.

The flowering shoots of the male plant commonly bear as many flower panicles as leaves, in which case neither the highest leaves nor the lowest leaf develop any panicles in their axils. The lowest leaves of the flowering shoot soon fall off and more readily expose the flower panicles to insects, while the highest leaves remain and tend to protect the blossoms from the direct sunlight, wind, and rain. The panicles are 7 cm. long and stand somewhat stiffly upright at a sharp angle to the axil of the attached twig. The longer ones bear about a dozen side twigs of the first order, of which the three lowest ones are about 2 cm. long and in their turn are again richly branched. Toward the tip the side twigs of the first order become shorter and are not further branched. They are formed like a bunch of grapes, and the end of a panicle is likewise visibly terminated by a flower. The same regularity, as nearly as could be determined, appears in the arrangement of the side twigs of the first order on the panicle stem as was noticed in the phyllotaxy. Minute woolly hairs appear on the panicles at the blooming time, particularly on the bases of the panicle stem and on those of the side twigs.

The flowers are placed singly on stalks from 4 to 7 mm. long, and have a diameter of from 5 to 7 mm. when fully opened. The flowers have 5 calyx leaves, 5 petals, 5 stamens, and one rudimentary ovule; only by way of exception do 6 or 8 stamens occur, and in one flower with 6 stamens 6 petals occurred also.

The calyx leaves are tongue-shaped and have broad bases. They are about 2 mm. long and have a dark green color.

The petals are long-elliptical in shape, narrowed at the base and at the point, and somewhat pointed in the front. They are 4 mm. long and in the middle about  $1\frac{1}{2}$  mm. wide. When in bloom the flowers are strongly bent downward. The color of the petals is light green, much lighter than that of the calyx leaves.

The stamens are  $2\frac{1}{2}$  mm. long. The white filaments, which are nearly twice as long as the anthers, shove themselves between the anther halves, which somewhat retreat from each other underneath. The anthers are introrse and are borne on upright but slightly curved filaments.

The rudimentary ovary forms a keg-shaped pivot about 1 mm. high, and has 3 discernible stigmas. Between the ovary and the anthers is a disk, which during flowering time glistens with nectar.

The flower, as viewed from above, is divided into 5 broad lobes, which stand in front of the petals and are separated by the insertion of the stamens; each lobe is again slightly indented in the middle. The outer and inner rims of the disk are somewhat arched toward the top; from this construction a ring-like depression appears in the middle.

While just as many inflorescences as leaves are found on the blossom shoots of the male plants, the number of panicles on the female plant is only about one half as great as that of the leaves. The leaves, however, are more numerous on the blossom shoots of the female. The number of leaves fluctuated between 7 and 9 in several investigations of shoots, while the number of panicles ranged between 3 and 5. As on the male plant, neither the lowest nor the highest leaves bear inflorescences in their axils but only the middle ones. The panicles have a length of 3 to 6 cm. They are not stiffly erect as in the male, but on the contrary only limply placed. The side twigs of the first order are up to 2.5 cm. in length, and have about as numerous branches, but shorter side twigs of the higher order than those of the male. The entire female panicle has about the same general outline as the male panicle. The anatomical structure of the panicle axis is essentially similar to that of the vegetative twig in the first year, and there is no noticeable difference in this respect between the male and the female panicle. Particular structures for tensile strength are not noticed in the axes of the fruit panicles. The stems of the pistillate flowers are not longer than 1 cm. and are often 5 mm. long. The flower itself is smaller than that of the male; its diameter, it is true, measures about 5 mm., but the petals are less curved.

The 5 calyx leaves are somewhat similar to those in the staminate flower, but slightly shorter. The 5 petals are spread out flatter and do not have the curled side rims. They are approximately 3 mm. long and 1.5 mm. broad. Five stamens also occur in the pistillate flower; their anthers are of nearly the same length as the fertile ones of the staminate flower, but the filaments are about 1.5 mm. long and therefore much shorter than those of the male. The anthers are shrunken, of a dirty yellow color, with pollen absent, so that the entire pistillate flower and panicles appear darker. As seen from the broad side, the pistil originates in a somewhat compressed, egg-shaped ovary which is extended in a short style. Toward the top the style spreads out into three thick, brownish stigmas which are beset with papilli. The ovary is also to be considered as constituted by three carpels, of which, however, two are rudimentary so that they appear only in the stigmas. Between the stamens and the ovary is the disk, which is similar to that of the staminate flower except that it is narrower because of the greater expansion of the ovary.

As far as the growth and the finer structure of the flower are concerned the male and female flowers show a great similarity. If one investigates young inflorescences on which the individual flowers are distinguishable as small buds, it is noticed that each flower stands in the axil of a com-

paratively large carrying leaf which somewhat overhangs the flower. The outside of the bract, as well as the stigma and the axil, are covered with upward-bent trichomes. These trichomes are of two forms, one a single long bristle hair and the other a short, apparently glandular hair with a single-celled base and many-celled ovoid head. These hairs are similar to those previously described as found on the leaves and stems. Further developed flowers, which, with their panicles, are 2 mm. long, have a hairy carrying leaf longer than the panicle. The calyx leaves, the petals, and the stamens lie alongside each other like small enlargements and finally the carpels arise as wall-like growths. In this instance, in which one can clearly recognize the construction of the bud, the stamens are egg-shaped and are covered by the short petals and the longer calyx leaves. Finally the disk shows itself between the gynoecium and the androecium. The course of the vascular bundles may very clearly be recognized in the mounted material, as resin ducts contained in the phloem have their contents turned brown. In the calyx leaf, which is formed with a broad base, 5 ribs appear of which the middle one is the strongest and most branched. On the other hand, the petal, which has a small base, has only one short, weak or unbranched rib on each side of the strongly branched midrib.

The disk appears in longitudinal section as a wide, somewhat sunken cushion. Toward the bottom its tissue is large-celled; above, on the other hand, it consists of small, closely united, plasma-rich cells, of the sort common to glandular tissues. Many small crystal clusters lie on the border of both tissues and in the upper, small-celled tissue, but are lacking in the lower, large-celled tissue. The epidermis consists of rather small polygonal cells and contains numerous stoma-like apertures whose guard cells are almost always larger than the other epidermal cells. A small space is found under the stoma-like opening. These openings apparently do not serve for gaseous interchange, but for the excretion of a glistening and strongly aromatic fragrant nectar whose existence has already been mentioned.

The development of the stamens in pistillate and staminate flowers is apparently similar to the time of the formation of pollen mother cells. In the pistillate flower no pollen grains are formed, the anthers remain empty, and have a shrunken appearance. The filaments of the pistillate flower remain as short as those of the staminate flower until the flowers open. The stamens naturally develop further in the latter. Pollen formation occurs in the anthers but shows nothing particularly noteworthy. The vascular bundles of the anthers contain no resin ducts, these having ended half-way up the filaments. The anther is also to a certain degree the only organ of the plant which has no resin-like or poisonous sap. It is not surprising then that the pollen has no toxic action on the human skin (17). Similar observations have been made by Inui (10) on the pollen of *Rhus vernicifera*, by Warren (29) on that of *R. Vernix*, and by Rost and Gilg (24)

on that of *R. Toxicodendron*. The pollen sacs of *R. diversiloba* are composed of two coalesced sporangia, as is common in angiosperms. Their dehiscence occurs by a longitudinal slit, developed where the two coalesced sporangia join. According to Edgeworth (4), the pollen of the Anacardiaceae is oval with 3 slits. The fresh pollen grains of *Rhus diversiloba* are ellipsoidal, about 1/800 sq. mm. in horizontal area, with a width 1/3 to 1/2 the length. The exine is roughened by minute, sharply pointed projections. When the pollen grains are immersed in N/4 KOH they assume a spherical form with no color change. In the material treated (which had been fixed in alcohol and xylol, stained, and mounted in balsam like the rest of the plant material), the spores assumed spherical shapes or in some instances became rounded tetrahedrons. As is common in entomophilous plants, the pollen has no surfaces so modified as to permit the wind to take hold of it, of the nature of the bladder-like appendages of the pine pollen, etc. Whereas anemophilous pollen has a dry outer covering to prevent large masses of pollen from adhering to the flower and hindering wind transportation, the entomophilous pollen of *Rhus diversiloba* is surrounded with a sticky substance so as to adhere to the feet and other parts of the insect. In common with other entomophilous flowers, *R. diversiloba* has perfume-secreting glands heretofore described which may serve to attract insects. The pollen itself being non-toxic and not wind-blown, the aerial transmission of the poison by the agency of pollen is quite out of the question.

As in the female flower the stamens develop to a certain advanced stage, so the ovary develops in the male flower to the extent that an almost fully developed ovule is produced. Such development of an ovule in a flower which is functionally purely staminate, borne on a purely male plant, is a phenomenon which has been but rarely observed. Each ovary contains regularly but one ovule. The funiculus becomes curved at its apex, so that the body of the ovule lies against it, and, although the axis of the body is straight, the micropyle is directed towards the surface of origin; thus the funiculus appears as a ridge along one side of the body of the ovule, and the ovule is anatropous and consequently of the form most common among angiosperms.

The ovule, in the mature female flower, fills the ovarian cavity. The outer integument, therefore, occupies considerable space. The micropyle is somewhat widely removed from the upper arching of the nucellus. The inner integument is widely tubular and lengthened outwardly over the nucellus, in which the embryo sac is again somewhat pressed back toward the inside so that a wider path is prepared for the pollen tube. The advantage of an anatropous ovule is apparent when it is remembered that the pollen tube advances along the wall of the ovary, and that the micropyle is thus brought near the wall. It is not surprising, then, that this plant with its efficient apparatus for fertilization should have large fruit production.

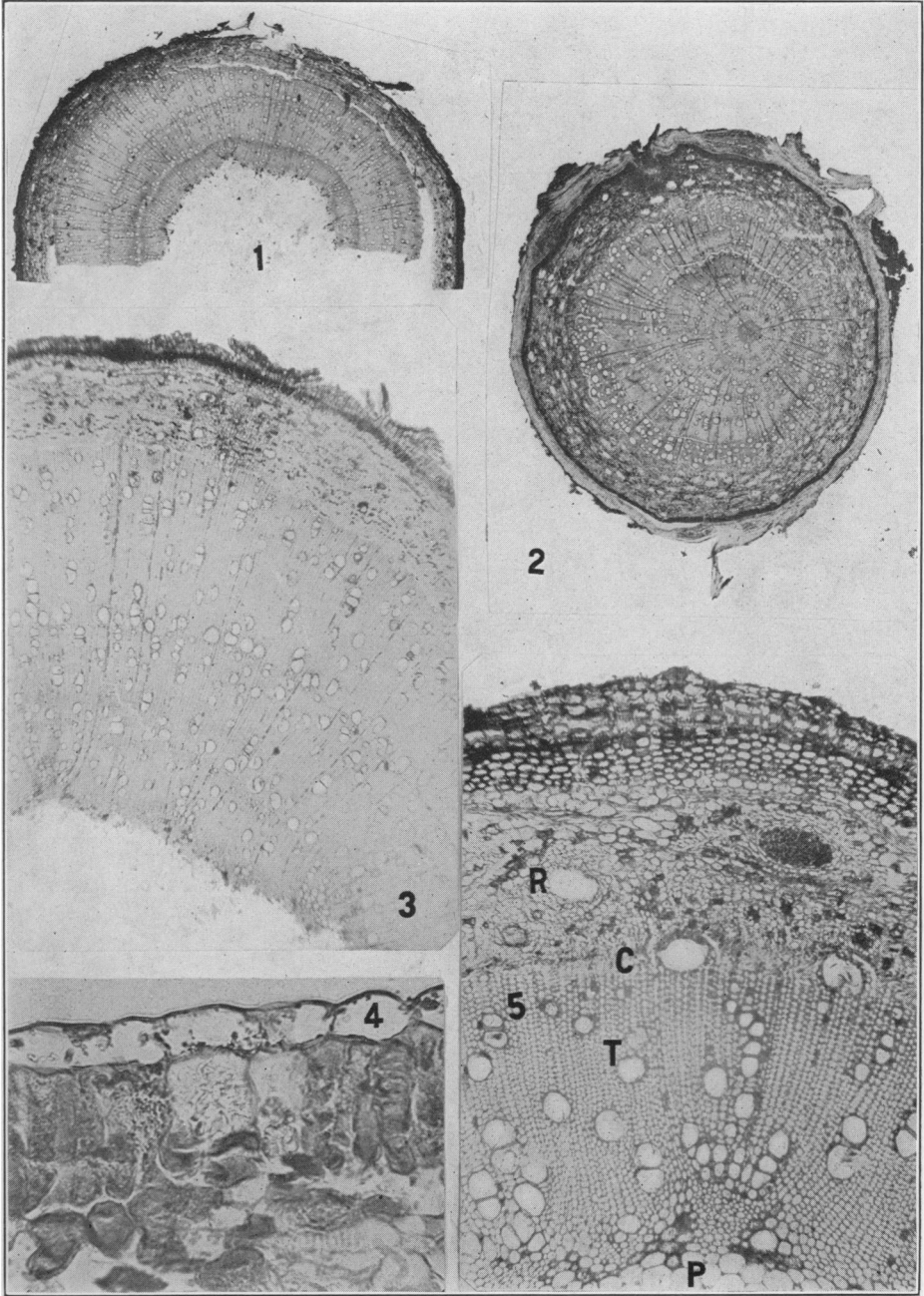
Numerous germinating pollen grains are found on the stigmas of open

pistillate flowers. The pollen tubes grow inside between the stigma papillae and pass through 4 to 6 cells of which the upper one is longest and thickest. On the stigmas of the staminate flowers such papillae are not formed, so that here no pollen grains are found. The wall of the ovary is penetrated by numerous vascular bundles with resin ducts which continue to the upper end of the pistil where the resin ducts terminate blindly with pointed ends.

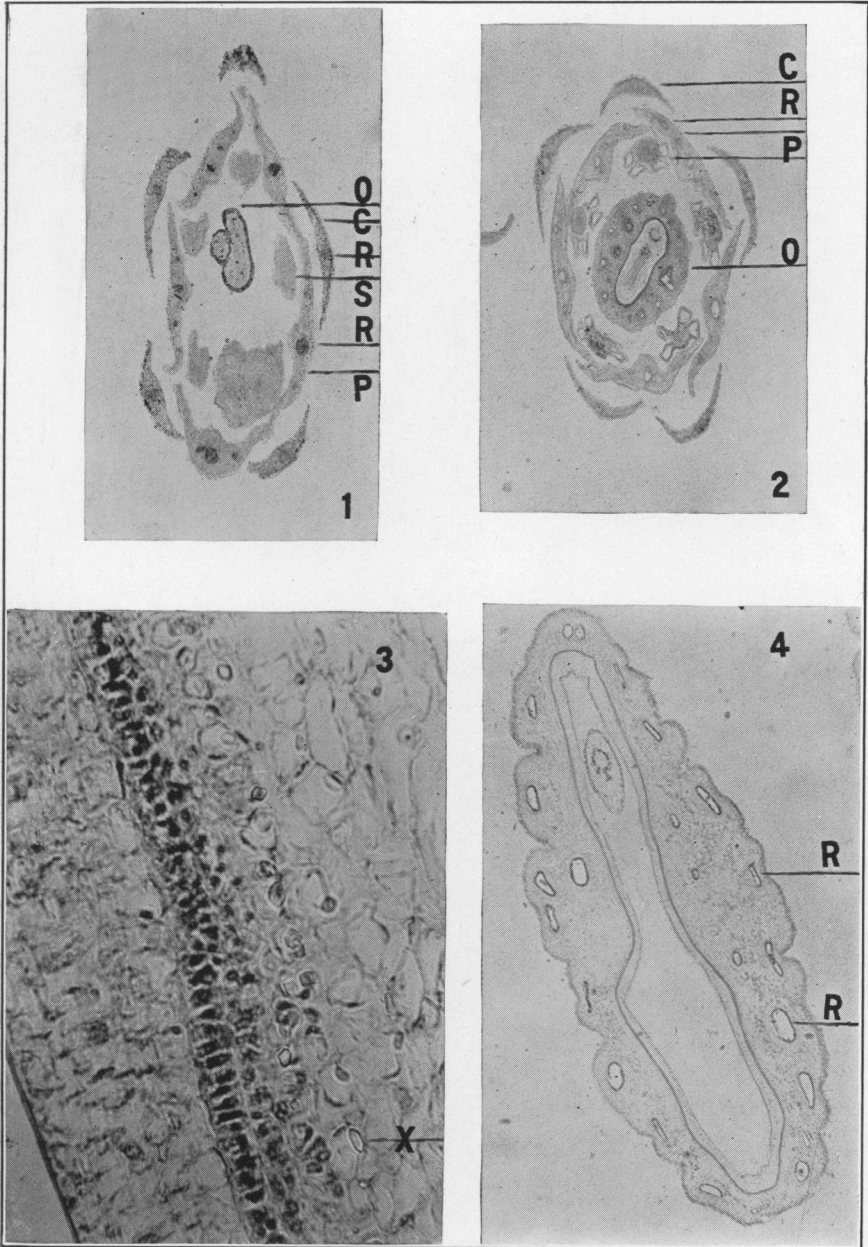
The development of the fruit, which terminates the life of the plant, has been taken up in another paper (19).

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### EXPLANATION OF PLATES

#### PLATE III

All figures have been reduced one half in reproduction and now show magnifications as follows: figure 1,  $\times 10$ ; figure 2,  $\times 10$ ; figure 3,  $\times 23.3$ ; figure 4,  $\times 470$ ; figure 5,  $\times 91.65$ .

FIG. 1. Transverse section through the same stem as in figure 3.

FIG. 2. Transverse section through a woody root.

FIG. 3. Transverse section through a stem older than that of figure 5, showing annual rings with their varied formations of spring and fall growth.

FIG. 4. Transverse section through mature leaf showing cystolith in palisade parenchyma.

FIG. 5. Transverse section through stem showing cork cambium; tracheal tube (*T*); pericycle with sclerenchyma cells or bast fibers and thin-walled pericycle parenchyma; phloem with resin duct (*R*); cambium (*C*); pith (*P*).

#### PLATE IV

All figures have been reduced one half in reproduction and now show magnifications as follows: figure 1,  $\times 23.3$ ; figure 2,  $\times 23.3$ ; figure 3,  $\times 470$ ; figure 4,  $\times 23.3$ .

FIG. 1. Transverse section through a male flower near its base, showing 5 calyx leaves (*C*) with resin ducts (*R*), 5 petals (*P*) with resin ducts (*R*), 5 stamens (*S*), and the non-fertile ovule (*O*).

FIG. 2. Transverse section through a female flower near its apex, showing 5 calyx leaves (*C*) with resin ducts (*R*), 5 petals (*P*) with resin ducts, 5 rudimentary anthers with neither pollen nor resin ducts, and the fertile ovule (*O*).

FIG. 3. Transverse section through an unripe fruit near the seed, showing numerous crystals. Size of hexagonal crystal,  $0.007 \times 0.0025$  mm.

FIG. 4. Transverse section through an unripe fruit showing an abundance of resin ducts (*RR*). Diameter of largest resin duct, 0.0085 mm.